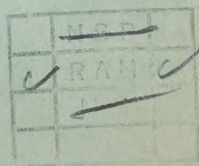


West African Maize Research Unit

Review of Research for the period
January 1955 — December 1957



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WEST AFRICAN MAIZE RESEARCH UNIT
REVIEW OF RESEARCH FOR THE PERIOD
JANUARY, 1955 to DECEMBER, 1957

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INTRODUCTION

1: General

Owing to administrative difficulties and staff changes it has not proved possible to issue annual reports. This report has been compiled to cover the three year period 1955-57 and is in the form of a general review of the major lines of work during the period concerned. More detailed accounts of the various projects are being submitted in the form of papers to appropriate journals.

The revised scheme for placing the Unit on an expanded basis, first proposed in 1955, has not yet come into effect. This new scheme involved small increases in both Senior and Junior establishments, increases much needed in view of the enlarged research programme, and also provided additional laboratory, office and store accommodation and glasshouses. The need for glasshouse space is particularly pressing in order to allow the testing of progenies in the seedling stage.

Shortage of staff and finances have greatly restricted the activities of the Unit and many highly desirable research projects in support of the breeding programme must be left in abeyance until additional staff and resources become available.

The breeding section has continued acquisition trials and these have been extended to all areas of Nigeria and Ghana to obtain germplasm suited to the various environments.

These trials are being made with the co-operation of the several Departments of Agriculture in the territories concerned, and their assistance is of great value to the Unit.

Basic breeding has commenced on a limited number of lines and a critical programme of testing the combining ability of inbred lines with their source varieties has begun. Until the present time the stress has been laid on obtaining high yields. Now that sources of yield have been found, attention will be directed towards the incorporation of resistance to diseases, principally rust and leaf blights.

The pathology section has been principally engaged on the biology and epidemiology of P. polysora. As the breeding programme developed it became apparent that rust is not the only problem of major importance. Attention is now being directed towards sources of resistance to the leaf blights of maize. One of the leaf blights, Cochliobolus heterostophus has excluded one Mexican variety from the breeding programme owing to its extreme susceptibility. Helminthosporium turcicum is a troublesome pathogen on most introduced varieties, especially the South American and Caribbean lines. A new disease, leaf fleck, thought to be caused by a virus, has affected many lines, both local and introduced, during the past two years and possible methods of transmission are being investigated. Greenhouse studies are principally concerned with the critical evaluation of progenies for resistance to the major pathogens.

The maize survey has now been completed for the Northern territories of Nigeria and Ghana. The northern maize types are predominantly flints. Only six flour samples were obtained in the survey and all were marginal, bordering on the Western Region of Nigeria. Only one dent was noted, this being from Eastern Ghana and thought to be a recent introduction. Full details of the maize survey have been submitted for publication.

11: Senior Service Staff

Several changes of staff occurred during the period covered by this report. The present staff, as at 31st December 1957, is given in Appendix I.

Mr. C.L.M. van Eijnatten, I.i. (Wageningen) assumed duties as Plant Breeder in April, 1956.

Mrs. C.E. Darter, B.Sc. Hort. (Lond.) was appointed temporary Technical Secretary in May, 1956.

Dr. W.R. Stanton transferred to the service of the Ministry of Agriculture, Northern Region, Nigeria, in November, 1957.

Mrs. C.E. Darter left the Unit in May, 1957, prior to proceeding on leave.

It has not proved possible to recruit additional members of staff owing to the proposed expansion of Establishment not having been given formal approval by Governments.

111: Junior Technical Staff

In October, 1956, Miss G. Ekpiken, formerly Agricultural Assistant in the Unit, returned as an Assistant Technical Officer, after three years' study in the United Kingdom at Agricultural Institutes in Usk, Monmouthshire, and Writtle, Essex.

Mr. N.N. Okparanta, Senior Agricultural Assistant, is shortly leaving for the United Kingdom on a six months study course in Plant Breeding methods at the Plant Breeding Institute, Cambridge.

Difficulty is being experienced in recruiting clerical and field staff owing to the lack of permanent establishment. It is hoped that eventually it will be possible to offer such members of the Unit Staff permanent, pensionable appointments under the establishment of the Nigerian Federal Government.

IV: Visits

During 1955 the Officer-in-Charge and the Mycologist visited Ghana at regular intervals. The Officer-in-Charge also visited Northern Region, Nigeria, during the course of the year and the Mycologist the Eastern Region and Cameroons and to Sierra Leone in November to consult records of maize pathogens at the Herbarium Department of Agriculture Headquarters, Njala. In November 1955, the Officer-in-Charge visited the territories served by the East African Agricultural and Forestry Research Organisation before proceeding on leave. On his return from leave in March 1956, he visited the Institut Francais D'Afrique Noire, Dakar, and M. Malamaire, Chef du Service Phytosanitaire du Gouvernement General de L'A.O.F. Whilst on leave, the Mycologist spent a period of study at St. Andrews University and visited Professor P.H. Gregory, Imperial College, London, to discuss problems of fungus spore dispersal.

During 1956 the three members of staff paid regular visits to the regions of Nigeria and Ghana. During 1957 the Plant Breeder visited Dahomey in May and the Ivory Coast in October. During his leave he paid visits to the

Statistics Department, Rothamsted Experimental Station and to the Institute of Plant Breeding, Cambridge, where he discussed the breeding programme with the Director, Dr. Bell.

As time and staff permitted these visits were designed to secure information of value to the work of the Unit and to maintain close liaison with workers engaged on related subjects throughout West Africa.

V: Visitors

Visitors to the Unit during the three year period have been numerous. Pre-eminent amongst these was Her Majesty the Queen in February 1956. Unfortunately both members of the Staff at that time were on leave. The work of the Unit was, however, demonstrated by Mr. J.E. Hardcastle, Botanist, Federal Department of Agricultural Research.

Sir James Robertson (Governor of the Federation) and Sir John Rankine (Governor, Western Region) paid visits both in 1955 and 1956.

Visits were also received from the Honourable Chief Obafemi Awolowo (Premier of Western Region) and M. Biros (Governor of Dahomey).

Messrs. J.E. Southgate (Chief Secretary, W.A.I.T.S) and A. Pickles (Secretary of the W.A.S.A.C.A.R.) were welcome visitors to the Unit on several occasions.

The list of other visitors during 1955 included:- Mr. F.C. Bawden, Rothamsted Experimental Station; Mr. J.R. Clackson, Director, Meteorological Service Lagos; Mr. Eastwood, Deputy Under Secretary, Colonial Officer; Professor C.T. Ingold, Birkbeck College, London; and Professor W.A. Lewis, Manchester University.

Visits were received in 1956 from:- Sir William Slater (Secretary of the United Kingdom Agricultural Research Council and Chairman of the Colonial Agriculture, Animal Health and Forestry Research Council); Dr. W. Carter (Director of the Pineapple Research Station, Hawaii); Mr. T.N. Hoblyn (Head of Statistics Department, East Mallang Research Station); Mr. F. Pinder (Director of Agriculture, Liberia); Mr. H. Jordan (Officer-in-Charge, Rice Research Station, Rokupr, Sierra Leone);

Dr. E.J. Hewitt (Long Ashton Research Station) and Professor R.L. Wain (London University).

Visitors during 1957 included:- Mr. J.W. Coopes (Liberian Secretary of Agriculture); Dr. Hendrikes (Secretary, C.C.T.A.); Mr. D. Rhind, O.B.E. (Secretary of Agricultural Research, Colonial Office); Dr. J.R. Raeburn (Reader in Agricultural Economics, London University); and Mr. G.W. Nye, C.M.G., O.B.E., (Agricultural Adviser to the Secretary of State for the Colonies).

VI: Publications

A number of Memoranda have been prepared during the period covered by this Report and these are listed in Appendix II.

It is proposed to continue the issue of Memoranda at intervals since these provide a rapid method of releasing information locally and form a basis for comment by the various Departments of Agriculture. In the past criticisms of the contents of these Memoranda have proved of value to the Unit in assessing the requests of the territories served and the research programme has been modelled accordingly. The Memoranda should only be considered as interim reports, completed projects being published in appropriate journals.

BREEDING AND AGRONOMY

1: Review

A breeding programme is designed on the basis of a scheme of acquisition trials in which all available seed material is tested under the various conditions encountered in the areas covered by the programme. This forms the agronomic basis of future breeding. The location of germ-plasm suited to Ghana's and Nigeria's different maize areas constituted the major part of the work carried out in many centres in both these territories. A rough outline of the several locations included in the trial scheme is given in Table 1.

Table 1: A summary of acquisition trials conducted in Nigeria and Ghana during the period 1955-1957.

ZONE	LOCATION	NUMBER OF TRIALS		
		1955	1956	1957
West rainforest	Ghana	3	2	-
	Nigeria	2	1	11
Dry rainforest	Ghana	1	1	-
	Nigeria	-	5	20
Southern Guinea Savannah	Nigeria	3	7	11
Northern Guinea Savannah	Ghana	2	1	-
	Nigeria	2	1	2
Montane	Southern Cameroons	-	-	2
TOTAL		13	18	46

Detailed results of these trials are available in the Unit's trial reports for 1954 and 1955 (mimeographed), for 1956 (mimeographed) and for 1957 (in preparation).

The variability of the growing seasons in successive years does not allow conclusions to be drawn from any one trial and the acquisition trials are, therefore, being continued to provide a broader basis for the comparison of individual varieties. Present non-orthogonalities in data are being corrected to provide a sound evaluation of maize varieties from different origins.

A number of preliminary recommendations have been made on the respective merits of a few varieties when grown under certain environmental conditions. The variety issued under the name of Mexico 5, proved its usefulness in a large number of trials conducted by WAMRU, and in a number of trials conducted by the various Departments of Agriculture. It is considered advisable to extend trials on varieties originating from Trinidad to the dry rain forest area and the Southern Guinea Savannah. Cuba Amarillo and varieties from Haiti proved to be of value in the wet rain forest area. Sicaragua consistently yielded well in the Southern Guinea Savannah.

In addition to the series of acquisition trials, which are being continued, breeding work has begun on a restricted number of varieties. The multiplication of acquired varieties and the practices of removing undesirable plant types has developed into a positive breeding process. The production of inbred lines from the desirable varieties, selected on the basis of results of the acquisition trials, is under way. An early testing of the combining ability of the S_1 lines with their source variety will enable the Unit to carry out a rigorous selection programme on a restricted number of lines, while retaining only the better combining ones.

During 1957 a programme was started to compare the performance of a group of widely differing varieties under the various environments prevailing in Ghana and Nigeria. A number of varieties were included which had already proved to be of value in a number of locations. This series of trials is being continued during 1958. It is envisaged that it will determine the suitability of different maize types to the more important West African environments.

A study was made on the floral biology of some maize varieties growing under Ibadan conditions. The correlations between the time from sowing till pollen shedding and from sowing till the first appearance of silks and their subsequent maturity time were investigated. Observations were made on the growth and receptivity of the silks when exposed, and when protected by ear bags used for controlled pollination.

The time required for the breeding programme is being shortened by growing a third annual crop of maize under irrigation during the months of the dry season. Observations were made on the efficiency of the irrigation apparatus.

A preliminary observation was made on the occurrence of resistance to the field population of stemborers at Ibadan in a number of lines introduced from U.S.A. These lines are known to carry resistance to the European Corn-borer, Pyrausta nubilalis.

11: Trials

The present system of trials can be divided into the following groups:-

- 1 Trials on selected varieties
- 2 Acquisition trials
- 3 Trials conducted for the improvement of varieties
- 4 Hybrid trials (combining ability tests)
- 5 Trials on resistance to stemborers

1: Trials on selected varieties

A large number of trials were conducted at many different locations to obtain a quick evaluation of the suitability of introduced varieties to the different areas.

To obtain a direct comparison of the results of such trials in the different locations the following method was adopted.

Selected varieties were multiplied from the original introduction without undergoing a positive improvement programme, and then used in a series of trials at many locations in the different vegetation zones. The trials are known as 'Cooperative' trials, since they are being carried out in cooperation with the various Departments of Agriculture. This project was started during the first season, 1957, and will be continued for two years.

The main object of these cooperative trials is to determine the suitability of a number of widely differing maize types of various origins to the various environments encountered in Ghana and Nigeria.

It is also hoped that information will be obtained on the possibility of restricting the number of trials to a small number of locations, locations which will give results applicable to a number of maize zones, along the West African coast. The detailed results of these trials are available in WAMRU's trial report for 1957 (in preparation). A complete picture of the results of this project can only be given after the completion of the 1958 cycle of cooperative trials.

2: Acquisition trials

Whilst awaiting the results of the scheme of co-operative trials, test plots for the evaluation of introduced varieties have purposely been distributed over a number of scattered locations within the main vegetation zones. The areas under consideration have been divided into the following vegetation zones.

- 1: Wet rainforest
- 2: Dry rainforest
- 3: Southern Guinea Savannah
- 4: Northern Guinea Savannah

A number of regions do not fit into these zones, although they cover a large part of the working field. Examples are the montane areas of the Cameroons, the Jos Plateau and the Accra Plain. Special studies are being made on the performance of maize varieties in such areas.

The respective stages reached in the evaluation of the various groups of maize varieties acquired by the Unit are briefly described. For more detailed results reference should be made to the Trials Reports.

Mexican Collection (acquired in 1952)

The first variety to be distributed in the dry rain forest and Southern Guinea Savannah was Mexico 1 (Coahuila 8), which yielded remarkably higher than the local varieties in this main maize area. In the 1953 Annual Report this variety was recommended for further investigation together with the varieties Mexico 5 and Sicaragua. A series of 23 extension trials, run by the Department of Agriculture of the Western Region of Nigeria proved that Mexico 1 gave a significant increase in yield over local varieties in the Southern Guinea Savannah and the drier parts of the rain forest belt. However, in the wet parts of the rain forest it gave yields lower than the local variety and grain of much inferior quality.

The variety Mexico 5 (Rocamex 520 C) is superseding Mexico 1 in yield, in many cases up to 30% higher. It proves to have a wider range of adaptability than Mexico 1. Together with Cuba Amarillo yields of over 60% higher than the local variety were obtained for Mexico 5 in centres

located in the wet rain forest area. The yields of the locals were in these cases, however, very low (500 - 800 lb/acre). Mexico 5 is replacing Mexico 1 both in the rain forest area and the Southern Guinea Savannah.

Mexico 7 (Papaloapan) is a somewhat yellowish dent variety, whereas the Mexico 1 and 5 are pure white dents. However, the Mexico 7 is promising in its performance and is being investigated further.

The varieties Mexico 13 (SLP - 20 4A) and Mexico 16 (Ver. 39-66B-1-3) show a satisfying yield level under dry rain-forest conditions and are considered worthwhile from the aspect of rust tolerance. Mexico 11 especially, often features among the higher yielders.

Central American Collection (acquired in 1954)

Fifty varieties of maize from Central America were received via the East African Agricultural and Forestry Research Organisation. A number of these acquisitions show a remarkable performance. Acquisition 766 was on the average far the best yielder in rain forest and Southern Savannah conditions. The origin of this variety is again the Rocamex 520 C, the same as that of Mexico 5. It considerably out-yielded the Mexico 5 introduced from Mexico in several cases.

A number of medium yielding, shorter maturing varieties are being selected from this group.

Caribbean Collection (acquired in 1953)

The indigenous maize varieties from the Caribbean Isles have been sampled and studied by W.L. Brown. WAMRU acquired this collection in 1953. The trials indicate that the most promising varieties are within the group of lines from Trinidad and San Domingo. These varieties must be listed under the longer-maturing ones (approximately 95 - 105 days). A bulk-variety composed from Haiti lines performed well under wet rain forest conditions. In drier areas however, they do not approach the yield level of the Trinidad lines.

Ten varieties from Martinique may be useful as source material for a breeding programme on shorter maturing flinty varieties. Their maturity time is approximately 70 - 80 days at Ibadan.

West African Varieties

The collection of West African local varieties may probably provide the Unit with a number of desirable maize types. A preliminary trial was made on approximately fifty varieties from various locations. The greater variation in yielding ability in this group of local varieties is remarkable. In one trial these varieties gave a range of 384 lb. to 1859 lb. dry grain per acre. Under second season conditions at Ibadan, where this trial was conducted, the yield of 1800 lb./acre compares very favourably with the yield of the Ibadan local variety (1250 lb/acre). These trials confirm the value of the cross-testing, within and between different vegetation zones, of local varieties originating from these zones.

Miscellaneous

The variety Sicaragua, a white dent variety, was introduced in 1952 from Venezuela. Although it gave a yield comparable with Mexico 1 in the rain forest, it was not accepted by the farmer in that area. Sicaragua was favourably received at a few centres in the Southern Guinea Savannah and on the black alluvial soil of the yearly inundated valley of the river Oueme in Dahomey. In these centres it outyielded all other introduced varieties.

The varieties Cuba Amarillo and La Creole have proved to be of value in such different areas as the Northern Guinea Savannah and the wet rain forest area.

Observations are being made on a number of varieties introduced from Florida, Kansas and Indiana (U.S.A.).

3: Trials conducted for the improvement of varieties

The system of acquisition trials followed by the comparison of selected varieties leads on to selection within individual varieties. A pilot trial on improvement methods was conducted and served as a guide for future work.

Trials on hybrids

During the first years of the Unit's existence a number of top cross hybrids were produced. However the combination of varieties could not be based on the results

of variety trials and even less on tests on the combining ability of the varieties concerned, as the results of such trials were not yet available at the time. Therefore, from the randomly produced hybrids only relatively few deductions could be made.

A hybrid program has now been started, as the results of variety trials are becoming available and a choice has been made on a standard group of tester-varieties. The production of hybrids from a number of tester parents of widely different origins will enable an estimate to be made of their combining ability.

The selected tester parents are

- 1: Mexico 5
- 2: Trinidad Bulk
- 3: Maritintque Bulk
- 4: Ashanti local Bulk
- 5: Ayinasi x Calabar local Bulk
- 6: Northern Flint local Bulk

The first steps in this program are being taken, being the production of the necessary homogeneous tester varieties.

As three of the testers are already available, the production of the different top-crosses of selected varieties from these testers has begun.

Trials on resistance to stemborers

In 1957 one trial was carried out to compare a number of crosses and back-crosses, including inbred lines, received from Minnesota (U.S.A.) and carrying resistance to the European Cornborer (Pyrausta nubilalis). The first back-cross of a hybrid of a Minnesota line with Mexico 1 to its Minnesota parent showed considerably less stemborer-attacked plants than the local variety, while the hybrid itself was much more susceptible.

III: Present improvement and seed multiplication system.

When a variety has proved of value on the basis of an extensive range of trials, it is then subjected to selection on the basis of adaptation to a certain area prior to its release. Whereas the main object of the selection is to obtain a high yield level, other important considerations must be taken into account.

1: The variety must be adapted to the very humid conditions prevailing at harvesting time. The grain must not contain more than 22% moisture. Introduced varieties mostly have 25% or more moisture and local varieties vary from 18 to 22% moisture.

2: The young seedlings must be tolerant to a drought period of a few weeks. At the beginning of the rains the rainfall distribution is most erratic.

3: Even when the main point of selection is resistance to rust, susceptibility to leaf blights is not tolerated.

4: When the variety is issued to farmers as an improved variety, they should be able to grow their own seed according to their normal practice. If the separation of unfavourable characters is not done thoroughly, even the first post-improvement generation will show a high percentage of unadapted plants.

The procedure adopted is to produce inbred lines from promising varieties and to perform an intra-variatal selection via these inbred lines, which are under continuous control when growing at Ibadan. The scheme of the varietal selection is described briefly.

The first stage inbreds are top-crossed to the source variety. The resulting top-crosses are tested on their yielding capacity. This method of the early testing of the inbred lines, advised by a number of American breeders, is being used only to separate the better-combining first stage inbreds from those with poorer combining ability. This procedure is based on the supposition that combining ability is determined early in the inbreeding process, although the lines certainly do not approach permanent stability before the fifth or sixth inbreeding stage.

The better combining first stage inbred lines are brought to an advanced inbred stage. A second test on the combining ability of the advanced inbreds then reveals which lines can be combined into a reliable synthetic variety. The first generation of this synthetic will be considered as the foundation seedstock, which will be issued to the Departments of Agriculture. The Departments will then under-

take a large scale multiplication in as few generations as possible. It is advisable to split the stock into a requisite number of parts according to different maize areas occurring in the territories concerned. This procedure will permit selection for environment. It is recommended that no interchange of seed stocks occur among the different areas. A source of seed must be retained within each area, preferably on a Government farm, until such times as seed producers are appointed.

The present improvement system has been started on a variety composed from a number of lines from Trinidad. This scheme, however, did not start with inbred lines, but with ear selections and therefore with only half-controlled parentage. Only the details on the topcross-yield trial are available as yet. The trial was placed late in the season and the yield level is therefore necessarily low. An analysis of this trial revealed treatment differences significant at $P = 0.001$. The analysis of variance is given in Table 1.

Table 1: Analysis of variance

Source	DF	SS	Variance	Ratio	Result
Replications	2	6.34	3.17	9.48	$P=0.001$
Treatments	55	46.59	.85	2.53	$P=0.001$
Blocks	21	13.55	.65	1.95	$P=0.05$
Error	39	29.78	.33		
Total	167	96.26			

The yield figures were placed into yield classes to study their distribution. In Figure 1 the curve for this trial is plotted. The theoretically expected distribution curve was calculated and drawn in the same figure.

The ability of the ear-selections to be combined one with the others into a synthetic variety, higher yielding than the parental source variety, will be expressed by the relative yield levels of the test crosses. The parental (source) variety was used as tester, because it can be

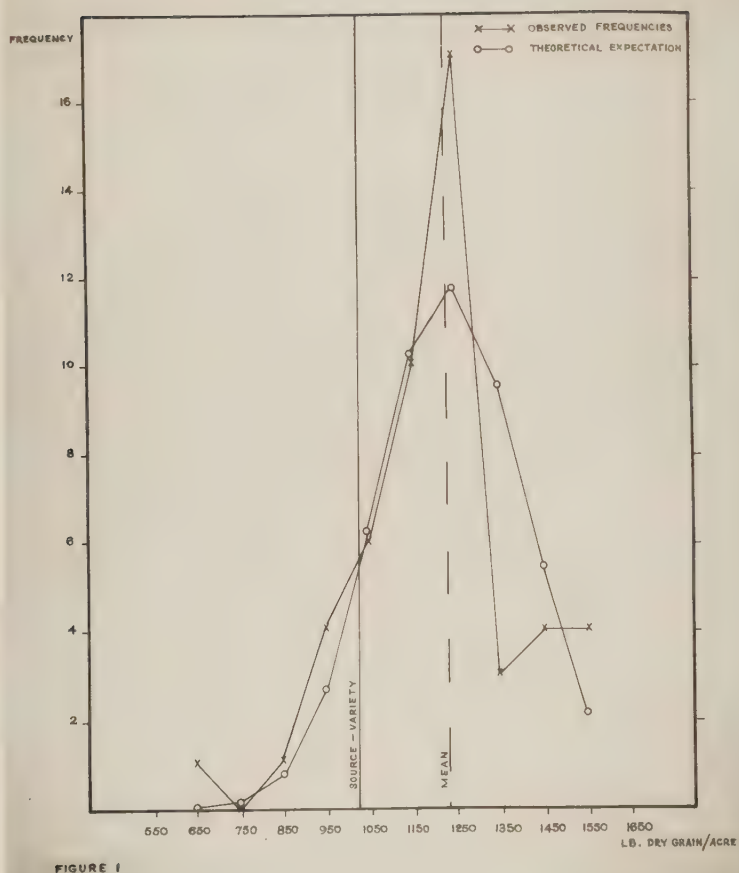


Fig. I Actual and theoretical yield distribution of Trinidad Bulk top-crosses

taken to represent partially the genotypes of all the ear selections. Therefore, the eight ear-selections, which are the female parents of the eight highest yielding test crosses, are being combined into a preliminary synthetic.

The improvement of this Trinidad variety is a pilot scheme on methods to be used in the selection of varieties. During 1957 the preliminary stages of this improvement procedure were started for Mexico 5, Tsolo, Sicaragua and Mexico 13. The necessary topcrosses for the evaluation of the S_1 - lines of Mexico 5 on their combining ability were produced during second season 1957. The first yield trials will be started in 1958.

IV: A Preliminary investigation on the resistance to West African Stemborers in Zea mays

A possible method of control of noctuid stem borers is by incorporating resistance in the host.

Painter (1951) and Perry and Dicke (1956) state that different strains of maize are known which contain resistance against the European Corn borer (Pyrausta nubilalis Hbn.), belonging to the lepidopterous family of the Pyralidae. The important West African stemborers belong to another lepidopterous family, the Agrotidae. It is possible that the stemborer (Pyrausta) - resistant maize strains from the United States corn belt will be of value for maize breeding work in West Africa.

Five inbred lines, carrying genes for resistance against the European corn borer, were requested and acquired from Dr. E.H. Rinke of St. Paul, Minnesota, U.S.A. (Stanton 1955a).

As no greenhouse or insectory accommodation was available for WAMRU's breeding work, it was decided to produce the hybrids of these Minnesota-lines with Mexico I (a selection from variety Coahuila 8 from the Rockefeller Foundation, Mexico) which is susceptible to stemborers, but gives reasonable yields compared with the stemborer-susceptible local varieties. Where possible the hybrids were backcrossed to either of the parents. Second and third backcross stages to the Minnesota parent were obtained also in a few cases.

In the second season 1957 six of the hybrids and back-cross stages were available in sufficient quantities to undergo a field test on resistance against stemborers.

Those are listed with their treatment numbers:

- Treatment 1: Minn. A42.645 x Mex. 1
- Treatment 2: (Minn. A42.645 x Mex. 1) x Minn. A42.645
- Treatment 3: (Minn. A294 x Mex. 1) x Mex. 1
- Treatment 4: (Minn. A404 x Mex. 1) x Mex. 1
- Treatment 5: (Minn. A404 x Mex. 1) x Minn. A404
- Treatment 6: (Minn. A404 x Mex. 1) x Minn. A404

A local variety was included as Treatment 7 in this trial, laid down as a randomized block with four replications.

Each plot was split and consisted of one row of thirty plants of the treatment and parallel to this a row of thirty plants of the same local variety, which formed treatment 7. The rows were chosen at random.

This method was chosen to measure the variability of stemborer incidence under the experimental conditions in the field. In the evaluation of field resistance against stemborers a knowledge of this variability is essential, for estimating the chances of the respective treatments escaping stemborer attack.

Eight half-weekly counts of total number of plants and number of (visible) stemborer damaged plants were taken from time of emergence. From the fifth week of growth, weekly counts were taken. The last count was made at harvest when the stems of the maize plants were split longitudinally for the detection of internal attack by stemborers.

The percentages of stemborer damaged plants in the tester variety at the different observation times are given in Table 1:

Table 1: The amount of borer infestation in the tester variety at intervals after sowing expressed as the percentage stands infested

Days after sowing	Percentage bored plants	Days after sowing	Percentage bored plants
6	0	57	18.4
8	0	64	14.9
12	17.0	71	14.5
15	10.9	78	14.4
19	8.7	85	14.1
22	11.5	92	13.3
26	15.9	99	12.7
29	13.2	106	14.3
36	18.5	113	13.1
43	20.7	120	14.3
50	20.2		

The counts of the different treatments follow closely the distribution in time of the stemborer damage in the tester variety.

The data obtained on the twelfth day after sowing were analysed. The analysis of the percentage of bored plants and of the actual numbers revealed no significant difference between treatments or replications, both for tester plots and treatment plots. Table 2 gives the analysis of variance both for the treatment plots and for the tester plots calculated on basis of percentages transformed to degrees (Fisher and Yates, 1953). However the coefficient of variation is very high.

Table 2a Analysis of variance (Treatment plots)

	DF	SS	Variance	Ratio	Result
Treatments	6	533.71	88.95	1.17	Not significant
Replications	3	293.20	97.74	1.29	Not significant
Error.	18	1360.20	75.58		
Total	27	2187.47			

Co-efficient of variation: 37%

Table 2b: Analysis of variance (tester plots)

	DF	SS	Variance	Ratio	Result
Treatments	6	333.48	55.58	1.48	Not significant
Replications	3	31.71	10.57	1.	Not significant
Error	18	676.57	37.59		
Total	27	1041.76			

Co-efficient of variation: 26%

The range of stemborer attack at this first observation is given in Table 3.

Table 3: Stemborer attack 12 days after sowing

Treatment	Name	Percentage Attacked
4	Minn. A404 x Mexico 1	25.6
7	Local	19.8
1	Minn. A42645 x Mexico 1	17.9
6	Minn. A404 ³ x Mexico 1	17.2
5	Minn. A404 ² x Mexico 1	14.1
3	Minn. A294 x Mexico 1	9.6
2	Minn. A42.645 ² x Mexico 1	8.4

The data obtained at harvest were fully analysed. After coding the percentages of bored plants (Fisher and Yates 1953) an analysis of covariance was done on the number of bored plants and the total number of plants per plot. The regression of the number of bored plants on the total number of plants appeared to be highly significant (at $P = .001$).

These results are listed in Table 4.

Table 4: Analysis of variance

	DF	SS	Variance	Ratio	Result
Regression	1	58.38	58.38	339	$P = .001$
Error	17	3.62	0.21		

An adjustment of the number of bored plants was justified, since the regression variance proved to be highly significant. The differences between treatments, adjusted for total stand count (the independent variable), proved to be significant also at $P = .001$. The results are given in Table 5.

Table 5: Number of bored plants in the various treatments adjusted for total stand count.

Treatment.	Name	No. of bored plants (adjusted for total stand count)
3	Minn. A294 x Mexico 1	39.8
1	Minn. A42.645 x Mexico 1	35.0
5	Minn. A 404 ² x Mexico 1	34.0
7	Local	32.8
6	Minn. A404 ³ x Mexico 1	31.0
4	Minn. A404 x Mexico 1	30.0
2	Minn. A42.645 ² x Mexico 1	25.0
Difference required at $P = .001$		1.5

Analysis of variance.

	DF	SS	Variance	Ratio	Result
Treatment Error	23	35.12			
Error	17	2.62	0.15		
Difference = Treatments (Adjusted for regression)	6	32.50	13.75	95.66	P .001

1: The Pattern of attack

The data in Table 1 show that the first damage by stemborer attack was noticeable around twelve days after sowing, which is about nine days after germination. At that time the tester already showed an average of 17% bored plants. It is presumed that the plants were infected immediately after germination.

After the initial wave of stemborer damage a second attack occurred at approximately the twenty-sixth day after planting, fourteen days after the first appearance of stem-borer damaged plants, and reached a peak of approximately 21% bored plants between the fortieth and the fiftieth day after planting. The percentage of visibly stemborer-damaged plants then levelled off to about 15%.

The pattern of the first attack on the experimental area shows a marked variability. The coefficient of variation for the tester rows is approximately 26% (see Table 2b). Although in other trials a gradient has been observed in the number of bored plants in some direction over the field, this was not noticed in the trials described. The large variability of stemborer incidence covers the differences between the treatments (see Table 2). No correlation could be detected between stemborer incidence in the treatment-rows and in the parallel running tester rows. As expected the coefficient of variation for the treatment rows is larger, namely 37% (see Table 2a). The differences between the treatments add to the natural variability of stemborer incidence.

2: Resistance against stemborers

The data obtained when the first wave of damage was apparent do not show any significant differences, probably because of the variability over the experimental area of the stemborer incidence. However, attention is drawn to the behaviour of treatments 1 and 2 in connection with the analysis of the counts at harvesting time.

The percentage of number of plants not attacked by stemborers is low for the hybrid Minn. A42.645 x Mexico 1 but high for the backcross of this hybrid to the Minnesota parent.

The analysis of the observations at harvesting time of the treatment rows shows again (Table 5) that only the backcross of Minnesota A42.645 x Mexico 1 to the Minnesota parent is significantly more **resistant** to stemborers than the local variety at $P = .01$. The hybrid itself is the most susceptible of all treatments. The influence of differences in stand count at harvesting time on the error estimate was removed by the application of a covariance technique. Therefore these two facts indicate the possibility of recessive genes for resistance against stemborers being present in the inbred line Minnesota A42.645.

Although the use of tester rows in each treatment plot could not be used for a covariance analysis on stem-borer incidence in this trial, it still remains advisable to include this type of control, especially when a trend of stemborer incidence (from neighbouring maize fields or trash areas) is likely to be present.

The analysis on a basis of percentages of bored plants suggests the probability of recessive genes for resistance against stemborers in the line Minnesota A42.645.

It is desirable to establish inbred lines from the backcross Minnesota A42.645² x Mexico 1 and to test them under controlled environmental (insectary) conditions for their resistance to stemborers.

V: Floral Biology

Many developmental features of the maize plant are altered by humidity, light intensity, day length and temperature. To assist local plant breeding practice, observations were made on the duration of the receptivity of silks, the influence of bagging the earshoots on silk receptivity and the relation of the number of days taken to pollen shedding, silk appearance and maturity.

1: The influence of bagging and pollination on the growth of silks

In planning breeding operations it is useful to know, in addition to the length of time from germination to the average time of silk emergence, how many days after their emergence the silks remain receptive, when drying starts, and how long the silks take to dry out completely.

Daily observations were made on a second crop of Tsolo maize, a variety commonly grown in the Ibadan area. The date of silk emergence was noted and silk length measured each day until growth ceased. Observations were made also on the time when silks started to dry out and when drying was completed.

The observations were taken on three groups of 25 plants:

Group I: The ear shoots were bagged with ear-bags on the appearance of the silks, pollinated four days later and covered up again.

Group II: Ear shoots were bagged, but not pollinated.

Group III: Control. The silks remained exposed to uncontrolled open pollination.

The ear bags were 15 x 7.5 cm. and made from thin brown kraft paper.

Summary of results

(1) Silk measurements: The silk lengths (in centimetres)

Table 1: Length of silks at different observation dates

Days after silk emergence	Length of silks in centimetres		
	With bag. Pollinated	With bag. Not pollinated	Without bag. Freely pollinated
1	2.06 $\pm$ 0.30	2.13 $\pm$ 0.33	2.99 $\pm$ 0.41
2	5.71 $\pm$ 0.36	5.81 $\pm$ 0.53	6.63 $\pm$ 0.58
3	9.14 $\pm$ 0.61	8.15 $\pm$ 0.71	8.46 $\pm$ 0.75
4	11.30 $\pm$ 0.74	11.20 $\pm$ 0.86	9.35 $\pm$ 0.81
5	11.94 $\pm$ 0.76	12.93 $\pm$ 1.02	9.37 $\pm$ 0.84
6	11.81 $\pm$ 0.86	14.55 $\pm$ 1.12	9.86 $\pm$ 0.97
7	13.18 $\pm$ 0.76	14.81 $\pm$ 1.19	9.73 $\pm$ 0.94
8	12.95 $\pm$ 1.17	15.82 $\pm$ 1.17	10.80 $\pm$ 6.86
9	-	15.98 $\pm$ 1.27	11.43 $\pm$ 0.58
10	-	16.94 $\pm$ 1.24	-
11	-	17.78 $\pm$ 1.04	-
12	-	18.23 $\pm$ 0.76	-
13	-	18.14 $\pm$ 1.14	-

(2) Maximum length. The times taken by the silks to reach their maximum length are given in Table 2.

A significant difference occurred in two cases only:

1: The pollinated silks (with and without bags) reached maximum length earlier than the unpollinated silks - (P = 0.01).

2: The length of the unpollinated bagged silks is significantly greater than that of the open-pollinated, unbagged, silks (P = 0.01).

Table 11: Maximum silk length, first drying symptoms and 100% dryness of the silks for the three groups of plants

Treatments	Maximum length		First drying symptoms	100% dryness
	Period in days	Length in centimetres	Period in days	Period in days
With bag. Pollinated	4.1 $\pm$.18	11.71 $\pm$.76	5.6 $\pm$.23	12.0 $\pm$.7
With bag. Not polli- nated	5.4 $\pm$.30	14.07 $\pm$ 1.19	7.5 $\pm$.38	19.1 $\pm$.9
Without bag. Pollinated	3.4 $\pm$.26	99.55 $\pm$.81	5.2 $\pm$.20	13.4 $\pm$ 1.0

(3) First drying symptoms. In some cases silks turned brown soon after bagging. In other cases, silks remained fairly fresh for a comparatively longer time before they died. In this latter case, death took place in many instances without the silks showing the browning symptoms.

The difference between the pollinated and unpollinated groups is not significant (see Table 2). However, when the silks are not pollinated they remain two days longer before starting to dry up ($P = 0.001$).

(4) 100% dry silk. In some cases a few small new silks emerged after the first silks started to dry up. These new silks dried up within two days, even when bagged and not pollinated.

These silks were not taken into consideration in determining the 100% dry silk stage. There is a noticeable difference (Table 2) between the pollinated groups. However, the silks which were bagged but not pollinated grew much longer and dried up earlier than the pollinated silks ($P = 0.001$).

(5) Correlations. Correlations were calculated between the maximum length of the silks, period taken to reach maximum length, the first drying-up symptoms, and the period needed to dry up completely. The correlation-coefficients are presented in Table 3.

Table 3: Correlation coefficients between the different observed characteristics of the silks in the three groups of plants

Group I - bagged, pollinated

	DAYS			
	Max. length		First symptoms	100% dry
Max. length in cms.	0.34	NS	0.10	NS
Days M.L.	-		0.75	$P=0.001$
Days F.S.			-	0.38

N.S. = Not significant

M.L. = Maximum length

F.S. = First drying symptoms of silk

Group II - bagged, not pollinated

	Max. length	DAYS		100% dry
		First symptoms		
Max. length in cms.	0.20 P = .001	0.32 NS		0.52 P = .02
Days M.L.	-	0.52 P = .01		0.28 NS
Days F.S.		-		0.16 NS

Group III - bagged, pollinated

	Max. length	DAYS		100% dry
		First symptoms		
Max. length in cms.	0.59 P = 0.1	0.27 NS		0.70 P = .001
Days M.L.	-	0.22 NS		0.65 P = .01
		-		0.73 P = .001

(6) Siling time and tasselling time. Silking time was calculated in days from planting till first appearance of the silks. Tasselling time was calculated in days from planting till the first stamens were shedding pollen. Statistically the three groups are comparable, as the treatments started after emergence of the silks. (See Table 4).
Table 4: Time to silk emergence and pollen shedding in days

Observation	Group 1	Group 2	Group 3	Average
Silking time	60.0 $\pm$ 1.0	56.2 $\pm$ 0.2	57.7 $\pm$ 1.0	58.6 $\pm$ 1.7
Tasselling time	56.7 $\pm$ 0.5	53.9 $\pm$ 0.5	58.0 $\pm$ 0.7	56.2 $\pm$ 0.4

Uncovered silks reach their maximum length after approximately four days. If the silks are kept constantly covered, they reach their full length in about 5.5 days.

Pollination is therefore likely to cause earlier drying of the silks. Neither the period after which first drying symptoms appear, nor that needed to dry them up completely, shows a significant difference between both pollinated (bagged or unbagged) groups. Thirteen to fourteen days after emergence of the silks the bags could

be removed from the silks (which were pollinated four days after emergence) without danger of contamination with pollen from external sources.

The unpollinated (bagged) silks need a longer period to dry up completely than either of the pollinated groups. From first symptoms of drying to 100% dry stage is respectively about twelve and eight days. Roughly three weeks were needed for the unpollinated, bagged silks to dry up completely.

The normal procedure of given tasselling and silking times on the basis of observations on twenty to twenty-five plants seems to be reliable only within a variation of four to five days, as the three groups grown under identical conditions give significant differences at the 1% level.

2: Relation between the period taken to pollen shedding, silk emergence and maturity

Owing to a variety of factors including disease attack, lack of water and stem borer attack, the observed maturity time of many introduced varieties of maize bears little relation to the maturity time under more favourable conditions. A study of existing data has, therefore, been made on the relationship between tasselling time, silking time and maturity time to obtain an approximation of maturity time under these more favourable conditions.

Data were available of:-

- (1) 119 Caribbean lines and 11 Mexican lines, which have a moderately long maturity time, ranging from 80 to 100 days.
- (2) 9 Minnesota lines or hybrids between Minnesotas and Mexico 1, having a maturity time of 75 to 95 days.
- (3) 19 Italian inbreds which are short maturing varieties, from 60 to 80 days, with two exceptions of 93 days.

The dates on which the plants reach tasselling stage, silking stage or maturity were each assessed from a sample of twenty plants and the time needed to reach these stages calculated from the sowing date.

Of the three available statistics, tasselling time, silking time and maturity time, the one which can be most easily and accurately assessed is tasselling time, on the basis of the observations of the time at which 50 per cent of the plants of a particular population are showing anthesis. From the data it appears that the regression coefficient of silking time on tasselling time is approximately equal to one ($b=1.01$) and shows a standard error of only 2% of its value. The relationship between these two statistics and maturity is less constant. From the different regressions, however, working values have been calculated for the period to maturity. See Table 5.

Table 5:

Tasselling Time	Silking Time	Maturity Time	Period from silk-emergence to maturity
30 days	34.7 days	59.6 days	24.9 days
40 days	44.6 days	71.5 days	26.8 days
50 days	54.5 days	83.5 days	29.0 days
60 days	64.4 days	95.4 days	31.0 days
70 days	74.3 days	107.3 days	33.0 days

The values for the silking and maturity times are calculated values from a given tasselling time. An interesting feature of the relationship between silking and tasselling is the shortening of the interval between these two statistics with increasing lateness of tasselling time and the elongation of the period from silk-emergence to maturity.

V1: Dry Season Maize cultivation by Irrigation

A third crop of maize can be grown during the dry season (December to March) by the use of irrigation. During the dry season 1956/57 an area of approximately 0.9 acres was irrigated.

The water was delivered through 'Rainmaster' overhead rotary sprayers by a centrifugal pump, driven by an 18 h.p. Lister Diesel engine. The field was irrigated from three locations thrice a week for one hour. The distribution pattern of the water was measured by placing six standard rain gauges of 5" diameter upwind and downwind in a straight line from the source at intervals of fifteen feet. Wind speed and direction during the actual irrigation hours were noted. The observations are listed in Table 1.

Both upwind and downwind sufficient water was precipitated to allow normal growth of maize within seventy-five feet from the source. At larger distances the maize plants were stunted and showed drought symptoms. Within the distance of seventy-five feet from the source precipitation varies greatly. For experimental purposes, where uniform conditions over the whole area are desired, the use of this irrigation equipment is not recommended. For breeding purposes, however, the method is satisfactory.

Table 1: See overleaf

	Date	Mean-Wind direction	Mean Wind Speed (m.p.h.) Converted to Stand. Height	Precipitation (in ins.) at Distance from source (in feet)					Maximum Distance from source in feet	
				15	30	45	60	75		90
UP	18/2/57	N	1.90	0.73	0.36	0.29	0.33	0.24	0.11	102
	20/2/57	W	1.43	0.97	0.47	0.44	0.43	0.18	0.02	100
	22/2/57	W	1.39	0.56	0.52	0.29	0.27	0.29	0.15	103
FROM	26/2/57	S	0.62	0.64	0.48	0.35	0.34	0.33	0.09	102
SOURCE	28/2/57	W	2.34	0.76	0.57	0.43	0.48	0.12	-	83
	1/3/57	N	1.55	0.64	0.46	0.28	0.24	0.19	0.03	96
Mean Value			1.54	0.72	0.48	0.35	0.35	0.23	0.07	98
DOWN	19/2/57	N	1.19	0.95	0.64	0.37	0.37	0.27	0.14	102
	21/2/57	W	1.11	0.75	0.45	0.39	0.46	0.32	0.10	102
	23/2/57	W	1.67	0.72	0.52	0.50	0.45	0.29	0.02	95
WIND	25/2/57	N	1.25	0.66	0.47	0.29	0.23	0.19	0.09	102
	27/2/57	E	1.23	0.60	0.34	0.25	0.23	0.22	0.17	110
	2/3/57	W	2.84	0.73	0.51	0.39	0.32	0.34	0.31	113
Mean Value			1.55	0.74	0.49	0.37	0.34	0.27	0.14	104

PLANT PATHOLOGY

1: Biology and Epidemiology of P. polysora

1: The pathogen in relation to climate

The rust assay, begun in 1953, and now completed, has given valuable information on the distribution of the disease in West African, and on the main climatic factors favouring or limiting the epiphytotic. The West African Coast affords near-optimum climatic conditions for rust development and accounts for the success of the epiphytotic in that area. The assay carried out in Nigeria and Ghana showed that the severity of rust is governed by two main factors - temperature and humidity, and that maximum intensity and spread occurs under conditions of an ambient temperature of approximately 80°F with a small diurnal and seasonal range, and consistently high humidity. Such conditions prevail along most of the West African Coast. Inland, towards the north, the rust is progressively limited by climate. Rust intensity has been related to vegetation zones, these zones being an expression of the interaction and summation effects of all the climatic factors prevailing. Using this method the following classifications can be applied to the incidence of rust in Nigeria and Ghana.

Rust Intensity

Vegetation Zone

- | | | | |
|---|-------------------------|----|---|
| 1 | Rust absent or slight | a) | <u>Sahel and Sudan Savannah.</u> Mean annual temperature 82°F with an annual range of 20°F and large diurnal range. Low average relative humidity. Rainfall 25-35". |
| | | b) | <u>Guinea Savannah.</u> Mean annual temperature 80°F, with annual range of 10°F and moderate diurnal range. Low average R. H. Rainfall 40-45". |
| 2 | Rust slight to moderate | a) | <u>Derived savannah with relic rain forest.</u> Mean annual temperature 80°F, annual range 10°F and small diurnal range. Humidity ranging from 90-95% R.H. Rainfall 40-50". |

- 3: Rust moderate to severe
- a) Lowland rain forest. Mean annual temperature 80°F with small annual range of 7°F and a small diurnal range. Consistently high humidity, 75 - 95% R.H. Rainfall 45 - 55".
 - b) Macgrove forest and Coastal fresh water swamp. Mean annual temperature 80°F and small diurnal range. Consistently high humidity, 85 - 95% R.H. Rainfall 70 - 120".

The results of this assay, in conjunction with experiments on the temperature and humidity requirements for germination of the uredospore show that P. polysora is strictly a 'tropical' rust and will never constitute a threat to temperate maize growing areas in its present form. This evidence is endorsed by the present limitations of the world spread of the pathogen.

2: Temperature and humidity requirements for uredospore germination

The optimum temperature for uredospore germination determined at Ibadan is 80°F . This is in close agreement with A.N. Saccas who found it to be 82°F in French Cameroons. At the optimum temperature for germination and in contact with a water surface, uredospores will commence germinating within two hours. Saccas reports within 3-4 hours at 82°F . If the uredospores are not in immediate contact with water both the percentage and rate of germination is lower.

Saturated relative humidity is necessary for maximum germination. At 100% R.H. and a constant temperature of 77°F , 90-95% germination occurs. At a controlled R.H. of 95.45% and the same temperature germination is 0-2% and germ tubes are rudimentary.

In the rain forest communities along the West African Coast germination of the uredospore and subsequent penetration of the host is greatly facilitated by the near-optimum temperature and humidity conditions.

3: The viability of the uredospore

In French Cameroons and Equatorial Africa, A.M. Saccas reports that under low humidity conditions the uredospore remains viable for at least six months, but germination progressively decreased from 92-35%. Viability determined experimentally at Ibadan has been found to be much shorter. A marked variation in viability was observed when uredospores were stored in small humidity chambers at a fixed temperature of 77°F. A range of approximate R.H. values was obtained by using dilutions of sulphuric acid as the controlling medium.

<u>Approximate Relative</u> <u>Humidity at 77°F (25°C)</u>	<u>Uredospore Viability</u> <u>in days</u>
.10	18
.25	16
.35	15
.50	42
.65	62
.76	60
.90	32
1.00	Mould developed in two days.

No germination counts possible.

Maximum viability at 77°F was obtained in storage at approximately 65% R.H., a value much lower than that prevailing under field conditions during the maize growing seasons.

Uredospores stored in containers under field conditions showed considerable variation in viability throughout the year. Table 1 gives the absolute viabilities of material collected at monthly intervals from observation plots. Viability was assessed by germination tests at five-day intervals.

Table 1: The seasonal variation in the viability of uredospores of P. polysora stored under field conditions

Month of collection of material	Viability in days (5- day intervals)	Mean max. temp.	Mean min. temp.	R.H. %	Rainfall (ins)
January	50	92.5	72.2	49.6	0.15
February	50	90.7	71.9	50.4	3.67
March	50	91.6	72.3	58.6	2.49
April	40	92.5	72.2	65.2	3.47
May	45	88.7	71.6	75.4	8.59
June	45	85.2	70.6	83.8	3.50
July	30	82.6	70.8	83.8	3.50
August	30	81.1	68.4	78.0	1.00
September	30	83.9	71.0	74.5	6.83
October	30	86.2	70.7	78.6	6.00
November	35	88.5	70.4	62.3	2.36
December	50	90.3	65.2	45.5	0.21

Mean monthly climatic data have been incorporated in Table 1 to illustrate the variation in viability in relation to weather. It is apparent that longer viability is associated with high day temperatures, low humidity and rainfall. During the months of the rains, when the reverse climatic conditions prevail, the viability is greatly shortened. In laboratory tests viability is shortened by prolonged exposure to high relative humidity and apparently this applies also to spores subjected to field conditions.

4: Infectivity of the uredospore

Experiments have been carried out to determine the inoculum density required to establish infection with P. polysora on seedlings of resistant and susceptible varieties of Zea mays.

Uredospores, collected from rust stocks on maize seedlings were added to a 0.1% solution of agar in distilled water and carefully mixed with a glass rod. The viscid solution aided even distribution of spores in suspension.

The concentration of uredospores per unit volume was determined with a "Thoma" blood-cell counting slide and thereafter a series of dilutions was made containing, approximately 5,000, 2,500, 1,000, 500 and 100 spores per ml.

An 'Agla' micrometer syringe was used to inoculate the seedling leaves, the seedlings being placed under the mounted syringe with the needle, blunted at the tip, touching the leaf surface. A volume of 0.01 ml. of the appropriate spore dilution was applied at various points on the leaf, forming 'infection droplets', and the seedlings immediately covered with polythene hoods for 48 hours. At the spore dilutions used, 0.01 ml. in each case should have given theoretical applications of 50, 25, 10, 5 and 1 uredospores respectively.

Table 1: The numbers of infections obtained on seedlings of a resistant and a susceptible variety of Zea mays on inoculation with different concentrations of uredospores of Puccinia polysora in suspension
(a)⁰ Susceptible variety: Lagos White

Theoretical No. of spores	No. of seedlings inoculated	No. of seedlings assessed	No. of seedlings infected
50	20	19	19 (100%)
25	20	17	16 (89%)
10	20	20	17 (85%)
5	20	19	15 (79%)
1	20	19	3 (15%)

(b) Resistant variety: Mexico 13

50	20	19	19 (100%)
25	20	18	17 (94%)
10	20	19	3 (15%)
5	20	19	3 (15%)
1	20	20	1 (5%)

With low levels of application (10, 5 and 1 spores) higher infection percentages were obtained in the rust susceptible variety than in the resistant. No significant difference in infection was apparent between resistant and susceptible varieties at high levels of application of uredospores.

It is hoped to develop this method for use in the critical evaluation of progenies for resistance to rust.

Single spore inoculations

In order to check the accuracy of the spore dilution method at low dilutions (theoretical application of 1 spore) and to devise a method of culturing pure lines of rust, several techniques of single spore inoculations have been tested. So far the micro-pipette method has proved the most successful.

A micro-pipette was drawn out to an internal diameter of approximately 100 μ . This was mounted on an hydraulic micro-manipulator and the free end connected to an 'Aglar' micrometer syringe by a short length of narrow bore, plastic tubing. The plunger of the syringe was spring loaded to the body to ensure that the head was always in contact with the micrometer. A cavity slide was filled with glass distilled water containing 0.1% detergent and uredospores tapped onto the surface. Single spores were withdrawn in small quantities of water and immediately transferred to the surface of the seedling leaf, the water forming an infection droplet. The seedling was then incubated at 80°F and saturated humidity for 48 hours.

During 1956 this method was tested on nine varieties of maize covering the full range of susceptibility to Puccinia polysora. The results are listed in Table 11.

Table 11: The infection percentage obtained on seedlings of resistant, intermediate and susceptible varieties of Zea mays on single spore inoculations with uredospores of P. polysora

Host susceptibility to rust	Variety	Percentage infection obtained
Resistant	Mexico 13 (SLP20 4A)	2
	Afro 880	8
Intermediate	Afro 53193	8
	Mexico 5	7
	Tsolo	5
	Br. 129 Haiti	7
Susceptible	Abakaliki Red Flour	21
	Yellow Tuxpan - 12	11
	Lagos White	23

Susceptible varieties all gave a high percentage infection, but the distinction between the resistant and intermediate varieties was not so marked. The results indicated that this method could be used successfully for obtaining single spore cultures of rust.

5: Variation in the dimensions of uredospores

In order to determine whether or not uniformity existed in the dimensions of uredospores an analysis was made of collections from different areas of West Africa. Samples of a hundred spores from herbarium specimens from each of the following locations were measured:

<u>Territory</u>	<u>No. of samples</u>
Sierra Leone	3
Ivory Coast	2
Ghana	2
Dahomey	2
Nigeria	14
Cameroons under British Trusteeship	3

Frequency distribution curves were constructed from 500 measurements of lengths and breadths of uredospores collected at Ibadan, Nigeria, during 1953, and all other West African samples listed above were subsequently compared with these curves. None departed significantly

from the size distribution of the Ibadan sample. An analysis of measurements of West African specimens is given in Table 1.

In 1956 F.C. Deighton supplied specimens of maize rust from South East Asia and adjacent islands and mentioned that uredospores from that area were apparently smaller than in collections from Africa. Six samples, each of a hundred spores, were measured from Malayan material and two from Christmas Island (Indian Ocean).

The analysis of these measurements is also given in Table 1.

Table 1: An analysis of the measurement of uredospores of P. polysora from collections made in West Africa and the Eastern Pacific

	West Africa	Malaya, Christmas Island
Mean length.	32.70 $\pm$ 0.14 μ	28.67 $\pm$ 0.23 μ
Mean breadth	24.79 $\pm$ 0.24 μ	22.59 $\pm$ 0.31 μ
Corellation coefft. of length to breath	-0.28	-0.31
Relative volume of spores	1.0	0.78
Mean difference of lengths	4.03 $\pm$ 0.38 μ	
Mean difference of breadths	2.20 $\pm$ 0.24 μ	

Subsequent measurements on material supplied by the Commonwealth Mycological Institute showed that the dimensions of uredospores from the Philippine Islands agreed closely with those from Malaya and Christmas Island but those from Borneo were larger than both the Eastern Pacific and African samples.

With the exception of Borneo the two main size groups are consistent with the two directional spread of the rust, westwards and eastwards, from its origin, the Caribbean area.

Insufficient evidence is available to determine whether or not distinct forms of the rust exist in the different geographical areas. Pure lines of maize supplied by the East African Agricultural and Forestry Research Organisation were grown in Malaya in 1956 and reacted to rust in the same manner as the East African race, E.A.I.

The dimensions of the uredospores of this race conform to all other African samples which have been measured.

With the assistance of the Commonwealth Mycological Institute and the Arthur Herbarium it is hoped to continue the study of the variation in the dimensions of the uredospores with location. Experiments have also been started to assess the effect of environment on the uredospore with special reference to size variation.

6: Classification and known host range

In the course of reviewing the world distribution and host range of P. polysora doubts have arisen whether or not the form of the rust present in the American Continent and the Caribbean is the same as that in Africa.

In the former areas the following hosts have been recorded.

<u>Tripsacum laxum</u>	Nash
<u>T. latifolium</u>	Hitchc.
<u>T. lanceolatum</u>	Rupr.
<u>T. dactyloides</u> L. (<u>T. monostachyum</u> Willd.)	
<u>Erianthus divaricatus</u> (L.) Hitchc.	
<u>Euchlaena mexicana</u> Schrad.	
<u>Zea mays</u> L.	

The many records of P. polysora on Tripsacum laxum in North, Central and South America and the Caribbean area are of special interest in the respect that no records of rust on this host exist from Africa. In 1945 clonal material of Tripsacum laxum Nash was introduced into Nigeria from Trinidad as a possible cattle fodder. This material was reported on the quarantine certificate as being heavily infected with Puccinia polysora Underw. The material was sterilized and multiplied. Clonal material of the original introduction has since been inoculated at Ibadan with uredospores of P. polysora taken from local Zea mays. Repeated attempts have failed to institute infection. T. laxum in the field at Ibadan, even when adjacent to heavily rusted maize plots, has never shown infection. It is hoped to arrange for cross-inoculation studies to be done in the West Indies and America.

Until this has been done no conclusions can be made but, on the basis of existing evidence, it would appear that the form of P. polysora on Zea mays in West Africa is not identical with that reported on Tripsacum laxum in the Americas and the Caribbean.

7: Life Cycle

The aecidial and pycnidial stages of P. polysora are unknown. During the course of observations on the rust a constant watch has been kept on associates of Zea mays in the field but no related aecidia or pycnidia have been found and, in the American Continent, the centre of origin of the rust; these stages are also unknown.

Teleutosori were first found in December, 1953, on maize growing at Ibadan. In December the mature maize crop is subjected to the Harmattan, a cold dry wind from the Sahara causing very low humidity during the day and cold dry nights. It is only at this time of year that teleutosori have been found. In the montane areas of Cameroons, at altitudes above 4,000 ft., teleutosori are more common.

A series of experiments were carried out in an attempt to induce germination of teleutospores. Since all physical and chemical stimuli employed gave negative results, the methods are only briefly summarised in Table 1.

Table 1: Experiments to induce germination of teleutospores of Puccinia polysora

Time of collection of material and the initial treatment	Additional treatment prior to germination test	Germination	Time of germination tests after collection of material
Collected December 1953 and stored in refrigerator	a: Stored at +5°C for 5, 10, & 20 days, then wetted and dried alternately two times	Nil	3, 6 and 12 months

Table 1 (contd.)

Time of collection of material and the initial treatment	Additional treatment prior to germination test	Germination	Time of germination tests after collection of material
1:	(b) Frozen at -5°C for 5, 10, 20 days, wetted and dried ten times and floated on distilled water for ten days	Nil	3, 6 and 12 months
	(c) Wetted and dried for 5, 10, 20 times and then floated on distilled water for ten days	Nil	3, 6 and 12 months
	(d) No further treatment. Floated on distilled water for ten days	Nil	3, 6 and 12 months
2: Collected December 1953 and stored in sealed tins in the field	Treatments as in 1a, b, c, and d	Nil	3, 6 and 12 months
3: Collected December 1953 and stored in the laboratory at 27°C and 50% R.H.	Treatments as in 1a, b, c, and d	Nil	3, 6 and 12 months
4: Collected December 1954 and stored in refrigerator at 10°C	(a) Material exposed to chloroform vapour for 1 minute and then immersed in 1% citric acid for 15 minutes	Nil	3, 6 and 12 months
	(b) Material immersed in acetic acid, N 0.1, N 0.01, N 0.001, for periods of 5 minutes to 4 hours	Nil	3, 6 and 12 months
	(c) Material immersed in sulphuric acid, N 0.01, N 0.01, N 0.001, for periods of 5 minutes to 24 hours	Nil	3, 6 and 12 months

Table 1 (contd)

Time of collection of material and the initial treatment	Additional treatment prior to germination test	Germination	Time of germination tests after collection of material
4:	(d) Lipoid solvents. Material immersed in undiluted acetone, ether, chloroform and carbon bisulphide for periods of 5 minutes to 30 minutes Treatments 4a, b, c and d were all washed in running water for one hour after immersion and then floated in distilled water for ten days	Nil	3, 6 and months
5: Collected December 1954 and stored in the field in sealed tins	Treatments as in 4a, b, c and d, followed by alternate wetting and drying, 5, 10 and 20 times prior to floating on distilled water (b) Treatments as in 4a, b, c and d with no further treatment	Nil Nil	5 and 6 months 6 months

On consideration of available evidence it is likely that P. polysora is a micro-cyclic rust, the pycnidial and aecidial (O and I) stages being absent. This, however, must only be a hypothesis at present, since extensive inoculation studies have not been done, either in the presumed area of origin of the rust, the Americas, or in any of the territories now affected. The theory that the rust is a micro-cyclic rust is strengthened by the failure to germinate teleutospores under experimental conditions in the laboratory.

Again, however, the physical and chemical methods employed to date have been far from comprehensive and the teleutospore may germinate when subjected to the correct stimulus or series of stimuli. It is possible that, in the course of evolution of the host-parasite relationship, the pathogen has become separated from its aecidial host and that the teleutospore has in consequence lost the capacity to germinate.

The rust is highly successful in the uredo-stage and the ease of continuity in the uredo-stage in its present environment may have resulted in the suppression of the sexual phase in the life cycle.

In the absence of further information on the life cycle, the rust may be classified provisionally as a micro-cyclic, antoecious Hemi-form.

The chance of the appearance of new, virulent strains of rust is lessened, though by no means eliminated, if the sexual phase of the life cycle is absent, as appears to be the case.

8: Liberation of uredospores from the host

An estimate has been obtained of the reproductive capacity of P. polysora with reference to the liberation of uredospores.

Groups of pustules were selected on potted maize plants in the greenhouse and protected from draughts. From emergence of the pustule until death of the host leaf, uredospores were removed from a known number of pustules with a cyclone spore trap twice daily. The spores were impacted onto the surface of 0.1% aqueous solution of gelatine in the collecting chamber of the trap. After thorough mixing the concentration of uredospores was determined with a blood-cell counting slide. With this method it was estimated that one uredosorus, growing on a rust susceptible variety, Lagos White, liberates 1,500 - 2,000 spores each day for a period of eighteen-twenty days from emergence. A rust resistant variety was found to liberate 600 - 1,150 each day for the same period. Each uredosorus on a susceptible host is therefore capable of producing $2.7 - 4.0 \times 10^4$ spores during the life span. On this basis a plant of the variety Lagos White infected at the seventh week of growth could discharge roughly 14×10^9 uredospores prior to its death. This high reproductive capacity explains the very heavy concentrations of uredospores occurring in the atmosphere at the peaks of the maize growing seasons.

9: Seasonal fluctuations in the uredospore content of the atmosphere

Seasonal fluctuations were determined in order to follow the pattern of the air spora in relation to the incidence of rust on the maize crops. By means of an automatic volumetric spore trap a direct relationship was observed between the air spore concentration and the availability of host plants.

In normal practice the first annual maize crop is planted in early April. By mid-May rust infection becomes apparent on the crop and by early June the uredospore content of the atmosphere in the vicinity of large acreages of maize rises above 500/cu. m. and the value is maintained until harvest in early July. Thereafter the spore concentration drops to less than 100/cu. m. by early September. The second crop is planted at the beginning of September and infection generally appears six weeks later and the atmospheric spore load rises rapidly once more to a concentration greater than 500/cu. m. This value falls sharply immediately after harvest in late November and by mid-December is less than 10/cu. m. The decline continues until January when the concentration is as low as 0.2/cu. m. This value is maintained throughout the dry season and begins to rise once again the following June when the first season crop is showing infection.

10: The primary epidemic threshold

During the years 1954-56, within which period the spore trap was running continuously, infection of the first season crop was not recorded each year until the concentration of airborne uredospores in the vicinity of the maize exceeded 5/cu.m. To this arbitrary value the term 'primary epidemic threshold' is given, since it is suggested that this may be the minimum concentration of uredospores which, dispersed uniformly in the atmosphere, can successfully initiate infection, and that values lower than that have an insignificant chance of alighting on a suitable infection court. The primary infection threshold is only applicable to the first season crop each year since at the time of starting of the second crop the spore concentration is within the range 40 - 90/cu. m.

This work is being pursued to obtain a possible method of forecasting the time of outbreak of rust each year.

11: The incidence of viable inoculum in the atmosphere

Uredospores trapped during the dry season were at first thought to have come from maize trash from the previous season. The discovery of occasional plots of rust infected maize grown under irrigation during the dry season raised the possibility of some of the spores trapped being viable. This was checked by trapping the spores on 2% malt agar. Some of the uredospores, which were definitely identified as P. polysora, germinated on this adhesive. The concentration of such viable uredospores was very low, averaging 0.08/cu. m., but significant in the respect that viable spores are present throughout the year, and suggests a possible method of carry-over of the rust from one year to the next.

SEED DRESSING TRIALS

During 1956 and 1957 some preliminary trials were carried out to determine the individual and combined effects of fungicidal and insecticidal seed dressings.

1: Thiram and B.H.C. Trial 1957

To determine the individual and combined effects of thiram and B.H.C. a randomised block with six replications was laid out in April 1957. A flint variety of maize was **used** which had been stored for nine months prior to planting. Three seeds were planted per hole at 18" spacing on 3 ft. ridges. The following treatments were employed.

- 1: 25% thiram at 0.2% w/w.
- 2: 20% gamma B.H.C. at 0.3% w/w.
- 3: 25% thiram at 0.2% w/w + 20% gamma B.H.C. at 0.3% w/w.
- 4: Control. No dressing.

Stand counts were made ten days after planting and the plants subsequently grown to maturity. Losses of stands during development, due to attack by noctuid stem borers (Busseola and Sesamia spp.) made an analysis of final stand count and yield impossible. An analysis of stand 10 days after planting gave the following results:

Source	d.F	S.S.	Var.	Var. ratio	Results
Treatments	3	1059.5	353.2	7.90	P = 0.01
Replications	6	385.0	64.2	1.43	N. S.
Error	18	800.8	44.9		
Total	27	2253.3			

Treatments means

Thiram + B.H.C.	145.29
Thiram only	134.14
B.H.C. only	131.43
Control	130.43

S.E. diff. treatment means = 3.87

Difference required at 5% = 8.13

Difference required at 1% = 11.14

The combined fungicide/insecticide treatment was significantly better than the other treatments and the control. There were no significant differences between other treatments.

11: Combined fungicide/insecticide seed-dressing trial 1957

A trial incorporating several combined fungicide/insecticide dressings was laid down at Ibadan (Dry Rain forest community), and at Samaru (Guinea savannah) in the early season, 1957. In addition to investigating various dressings the effect of other factors such as seed coat character and time of planting were considered. The trial design was a 3^2 factorial arranged in blocks of three plots each split into sub-plots. The main treatments had three replications in each, the J component of the second factor interaction being confounded.

Main treatments

3 varieties (V)

V₀ (Fint)

Trinidad bulk

V₁ (Dent)

Mexico I

V₂ (Flour)

Abakaliki red flour

3 planting dates (T)

T₀

Two weeks earlier than normal

T₁

Normal

T₂

Two weeks after normal

Sub treatments - Seed Dressings

1	"Fernasan" B (FB ₁)	Thiram +	at 0.3% w/w
2	"Fernasan" B (FB ₂)	gamma B.H.C.	at 0.5% w/w
3	"Fernasan" D (FD ₁)	Thiram +	at 0.3% w/w
4	"Fernasan" D (FD ₂)	gamma B.H.C.	at 0.5% w/w
5	"Dioldrex" A (DA ₁)	1.25% mercury	at 0.3% w/w.
6	"Dioldrex" A (DA ₂)	20% Dioldren	at 0.5% w/w
7	"Dioldrex" B (DB ₁)	10% T.M.T.D.	at 0.3% w/w
8	"Dioldrex" B (DB ₂)	75% Dioldren	at 0.5% w/w
9	Control (C)		no dressing

At Ibadan the first planting was done on the 16th March and the last on 15th April. Three seeds were planted per hole at 18" spacing on 3 ft. ridges. The plots were neither thinned nor supplied. At Samaru the first planting was done on the 7th June and the last on 5th July. In both experiments germination counts were made seven days after planting.

Results (A) Ibadan

Analysis of Variance

Source of variation	D. F.	S.S.	M.S.	V.R.
Blocks	8	8651		
Time of planting (T)	2	20417	10202.50	20.91 (P=0.001)
Varieties (V)	2	16218	8109.00	16.21 (P=0.001)
T x V (uncounfounded)	2	24	12.00	0.02 (N.S.)
Error (a)	12	6002	500.17	
Main Plot total	26	51312		
Seed dressing (S)	8	792	99.00	1.12 (N.S.)
T x S	16	1238	77.37	0.87 (N.S.)
V & S	16	1670	104.37	1.18 (N.S.)
T x V x S	16	1356	84.75	0.96 (N.S.)
Error (b)	160	14158	88.49	
Sub-plot Total	242	70526		

S.E. of one sub-plot = ± 9.41 stands = 15.34% of G.M.

Summary of mean stand counts per sub-plot

Time of planting (T). Highly significant ($P = 0.001$)

2 weeks earlier than normal (t_0) = 48

Normal time (t_1) = 67

2 weeks after normal time (t_2) = 68

S. E. = ± 2.48

Varieties (V) Highly significant ($P = 0.001$)

Flint (V_0) = 69

Dent (V_1) = 50

Flour (V_2) = 66

S. E. = ± 2.48

Seed dressing produced no significant effect on germination in this trial. Effects of time of planting and variety were highly significant. Early planting reduced germination and this may be explained partly by the highly soil temperature and moisture content present at the time of first planting on the 16th March. The soil was exceptionally dry, no rain having fallen since the 3rd of March. On the 16th March, the soil temperature at 1 ft. was 91°F and 0.67 inches of rain fell reducing the soil temperature to 90°F . Planting under these conditions of high soil temperature and humidity may have adversely affected subsequent germination. At the time of the second planting the soil temperature had dropped to 87°F . The dent variety was most affected by early planting.

There were no significant interactions in this experiment.

Results (B) Samaru

A full analysis of this trial was not made. The results did not justify it.

V	V_0	V_1	V_2	Totals	%
T_0	3533	2809	3873	10215	60.1
T_1	2278	1413	2586	6277	36.9
T_2	3645	2899	4034	10587	62.2
Totals	9456	7121	10493		
%	55.6	41.9	61.7		

Seed dressing	Total plants	%
FB ₁	3007	53.0
FB ₂	2986	52.7
FD ₁	2914	51.4
FD ₂	3054	53.8
DA ₁	3036	53.5
DA ₂	2986	52.7
DB ₁	3135	55.3
DB ₂	3017	53.2
Control	2935	51.8

Germination on the whole was low and averaged 53.0%. The seed dressing produced a slight beneficial effect on germination. Time of planting and variety affected germination counts similar to the Ibadan trial. Germination in the second planting was very low, averaging 36.9% and again, as in the Ibadan trial, the **dent** variety showed the lowest germination of all. In the ten days prior to the second planting rainfall was very low and falls totalled only 1.62 inches. Only 0.1 inches was recorded during the week following planting and this drought would be largely responsible for the reduction in germination percentage.

On the basis of these preliminary experiments it is difficult to assess the value of seed dressings. Trial I shows that a combined fungicide/insecticide dressing is more advantageous than any one of the components alone. Trial 2 proved of little value, principally due to the adverse climatic conditions prevailing at the time of germination of some treatments. It is suggested that high soil temperatures and humidity may induce a toxic effect with some treatments due to an increase in the permeability of the seed coat to some dressings. 'In vitro' tests at present in progress support this and considerable work remains to be done before any recommendations can be made on the use of seed dressings on maize.

NEW DISEASES

I: Leaf Fleck

In 1955 a number of South American varieties of maize growing at Ibadan showed a translucent leaf spotting. The following year the incidence of this new symptom was greatly increased and was observed on twenty-eight out of ninety local West African varieties as well as on introduced lines from America and the Caribbean area. The first indication of the disease is the appearance of small, circular, translucent spots near the tips of the older leaves. These spots, approximately two -three mm. in diameter are confined to the intervascular areas. The spots gradually progress towards the base of the leaf and in some very susceptible varieties the intensity of spotting was seen to be as high as 22/sq. cm. Within a short time the tip and margins of the affected leaf show browning and die-back, with death of the leaf within ten days. The initial and final symptoms of this disease are very similar to those of virus leaf fleck of maize described by W.N. Stoner in California. In 1957 the appearance of the leaf fleck coincided with an unusually high incidence of the maize aphid, Rhopalosiphum maidis which Stoner showed to be a vector of virus leaf fleck.

All mechanical methods of transmission so far employed have failed to transmit the disease to seedling maize. Attempts at transmission by field populations of aphids have also been unsuccessful.

II: Water Spot

A peculiar water spotting was observed on leaves of the variety Tsolo during 1957. The spots are oval, 0.5 - 2.0 cm. long, 0.2 - 0.8 cm. wide, translucent and water soaked in appearance, and uniformly distributed over the entire leaf surface of the plant. No organisms could be isolated and the cause is yet unknown.

III: Stunting

The principle manifestation of this symptom is a marked stunting of the plant and complete suppression of the reproductive phase. The young leaves remain in a tight whorl, are often distorted and wrinkled

and the youngest show areas of white, transparent tissue at the base. Examination of these areas shows the mesophyll tissue to be suppressed.

GLASS HOUSE STUDIES

Available glasshouse accommodation is not adequate and has severely limited the testing of progenies in the seedling stage. The routine testing of lines for rust resistance has continued and now that inbred stocks are available a critical evaluation of resistance has commended. It is likely that the source of rust resistance to be incorporated into the first synthetic will be from derivations of Mexico 13 (SLP 20 4A).

A quantitative method for assessing seedling resistance to Cochliobolus heterostrophus is now being used and consists of spraying the seedlings with a known concentration of conidia in suspension, and counting and measuring the resultant lesions on the seedlings. No varieties resistant to Cochliobolus have been found yet.

The question of the existence of forms of P. polysora must remain unanswered until suitable glasshouse accommodation is made available. Mixed reaction types have been obtained on seedlings of some inbred lines using field inoculum.

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APPENDIX I

SENIOR STAFF DECEMBER 1957

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|----|-------------------|--|
| 1: | OFFICER IN CHARGE | VACANT |
| 2: | MYCOLOGIST | R.H. Cammack, B.Sc. Ph.D.
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| 3: | PLANT BREEDER | C.L.M. van Eijnatten, L.i.
(Wageningen) |

APPENDIX II

- 1: Memoranda: The following memoranda have been distributed during the period covered by this review:
- No. 4 Notes on Maize breeding procedure as applied to West Africa. June 1956. (W.R. Stanton)
 - No. 5 Estimation of Yield in Maize Trials where a number of the plots have a very low Stand Count. June 1956. (W.R. Stanton)
 - No. 6 Notes on the more important Fungi affecting Maize in Nigeria. July 1956. (R.H. Cammack)
 - No. 7 Notes on the Introduction of Puccinia polysora Underw. into Africa. June 1956. (R.H. Cammack)
 - No. 8 An analysis of the Measurements of Uredospores of Puccinia polysora in West Africa. July 1956. (R.H. Cammack)
 - No. 9 Notes on the care of Seed Maize under West African conditions. October 1956 (W.R. Stanton)
 - No.10 Observations on the Infestation at Harvest of the Ears from a trial of eight Maize varieties. September 1956. (W.R. Stanton)
 - No.11 Correlations between silking time, tasselling time and maturity time under Ibadan conditions. October 1956. (C.L.M. van Eijnatten)
 - No.12 Notes on a visit to the East African Agricultural and Forestry Research Organisation Territories. October 28th to December 1st, 1955. (W.R. Stanton)
- 2: Papers and Communications: The following papers have been submitted for publication during the period covered by the report:
- CAMMACK. R.H. (1955) Seasonal changes in three common constituents of the air spora of Southern Nigeria. Nature, Lond. 176, 1270 - 3



- CAMMACK, R.H. (1957) A new virus affecting maize,
Commonw. Phytopath. News. 3(4)61-62.
- " " (1957) Studies on Puccinia polysora
 Underw. I. The World distribution
 of forms of Puccinia polysora.
Trans. Brit. Mycol. Soc. (in press)
- " " (1957) Factors affecting infection
 gradients from a point source of
Puccinia polysora in a plot of
Zea mays. Ann. appl. Biol.
 (in press).

